

ZERO DRAFT REPORT

BARRIERS TO ENERGY USE EFFIECIENCY

Barriers to Energy use efficiency

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Barriers to Energy Use Efficiency

Background

The primary commercial energy supply in India comprises of coal (61.3%), oil (26.5%), natural gas (9.2%) and primary electricity (3%). The overall supply of commercial fuel has grown from 202 Million Tonnes of Oil Equivalent (MTOE) in 1991/92 to 245.3 MTOE in 1997/98 with a compound annual growth rate of 3.3%, whereas final commercial energy consumption increased from 130.7 MTOE in 1991/92 to 176.08 MTOE in 1997/98 with an annual growth rate of 5.1% (TERI, 1999). The higher growth rate of commercial energy consumption as compared to supply can be explained by more efficient conversion of primary energy to secondary or delivered energy. The sectoral commercial energy consumption pattern shows that the industrial sector is the largest consumer of energy (47.8%), followed by transport sector (23.6%), residential sector (9.77%) and agricultural sector (4.96%), the balance 13.87% being consumed by other sectors. The trends for energy use intensity for the period 1980 to 1997 for industry and transport sector, which together consume about 71% of the final energy are shown in Figures 1 and 2.

Figure 1: Energy Intensity for Industrial Sector

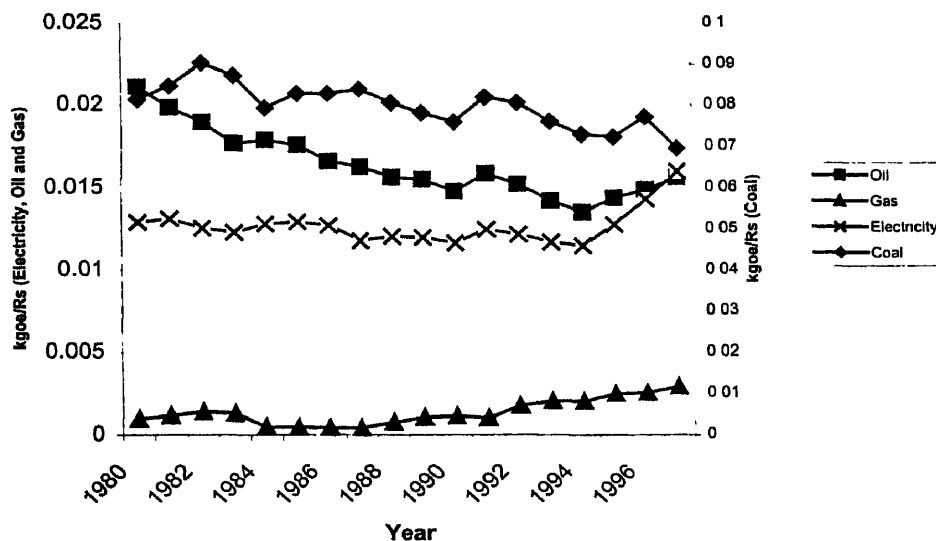
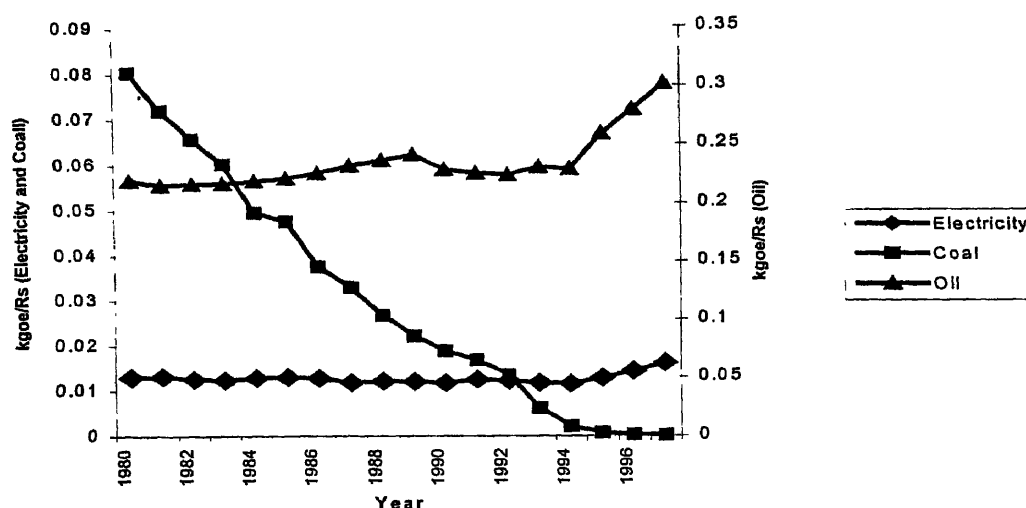


Figure 2. Energy Intensity for Transport Sector



The energy intensity trend for industrial energy use shows that the intensity for coal has declined from 0.08 kgoe/Rs. in 1980 to 0.07 kgoe/Rs. in 1997. Intensity for electricity has increased from 0.013 kgoe/Rs. in 1980 to 0.065 in 1997. Intensity for oil has increased from 0.021 kgoe/Rs. in 1980 to 0.062 kgoe/Rs. in 1997 and for gas it has increased from 0.001 kgoe/Rs. to 0.01 kgoe/Rs. during the same period. In the transport sector, intensity for oil has increased continuously from 0.22 kgoe/Rs. in 1980 to 0.30 kgoe/Rs. in 1997, whereas intensity for coal has declined from 0.49 kgoe/Rs. in 1980 to 0.001 kgoe/Rs. in 1997. The intensity for electricity has remained constant for this period. The reasons for declining intensity for coal is the planned phase-out of coal-based steam engines in the railways (decrease in steam engines from 7469 in 1980/81 to 64 in 1997/98) (TERI, 1999).

Energy Use Efficiency in Various Sectors

Despite the decline in energy intensity for some fuels in some sectors, there is substantial scope for improvement in energy use efficiencies. The existing energy use and scope for its efficient use in sectors like power, industry and transport are discussed in following sections.

Power Sector

The present installed capacity for power generation in India is about 90000 MWe (73% thermal, 25% hydro and 2% nuclear). The plant load factor (PLF) for thermal

power plants was about 64.7% in 1997-98 and the reported Transmission and Distribution (T&D) loss for 1997/98 was about 22% (Planning Commission 1999). However, in the states undergoing power reforms (Andhra Pradesh, Delhi, Haryana and Orissa), proper accounting for electricity losses has revealed much higher T&D losses (32% – 50%) for the year 1997/98. In addition to cutting down T&D losses, it is estimated that demand side management (DSM) programmes can also reduce the power demand by about 25000 MW by the year 2010 in India. The cost of saved electricity demand works out to US \$ 155/kW as compared to capital investment in power generation which is about US \$ 1100/kW (Reddy and Parikh 1997). There are also significant environmental benefits of DSM in terms of reduced fuel consumption and consequently reduced emissions of CO₂, SO₂, NO_x and fly ash.

Industrial Sector

The industrial sector consumes about 50% of total commercial energy produced in the country. Within the industrial sector, energy consumption is concentrated in a few industries, with seven energy intensive industries consuming nearly 80% of total industrial energy consumption. These industries are fertilisers, aluminium, iron and steel, textiles, cement, chemicals and pulp and paper. Although in the case of cement sector, the newer plants compare well with the best plants in rest of the world in terms of energy efficiency but energy efficiency in sectors such as steel, pulp and paper, fertiliser, etc. is well below that of other industrialised countries. A comparison of energy use in some of the energy-intensive industrial sectors in India and their counterparts in developed countries is shown in Table 1. In addition to these large industries, small and medium scale industries in the country (about 3 million units) are also energy inefficient due to use of old and non-standardised technologies. There is therefore substantial scope to improve the end-use energy efficiency in the Indian industry. It has been estimated that the total conservation potential of the industrial sector in India is around 25% of its total energy. Around 5%-10% energy savings are possible simply by better housekeeping. Another 10%-15% energy savings are possible with low-cost retrofitting, use of energy efficient devices and controls, etc. (TERI 1998).

Table 1. Comparison of Specific Energy Use in Select Industries (in million kcal/tonne)

Country	Steel	Pulp and Paper	Fertiliser
India	9.50	11.13	12.23
UK	6.07	7.62	11.25
USA	6.06	9.70	11.32
Japan	4.18	-	-

Sweden	5.02	7.56	-
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Source: TERI, 1999.

The scope for increasing energy efficiency in some of the energy intensive industries is highlighted in the box 1 below.

Box 1: Scope for Energy Efficiency in Indian Industry

- The **fertiliser** industry alone accounted for 44% of natural gas consumption in the country in 1997, higher than the share of the power sector, which stood at 40% (Planning Commission 1997). The energy efficiency of the fertiliser industry could be improved by the construction of new natural gas based plants and replacing old coal based plants. Revamping measures could be undertaken to improve the efficiency of old naphtha and natural gas based plants.
- Energy accounts for nearly 40% of the total cost of **aluminium** production. Electricity, coal and fuel oil are the major forms of energy used, with electricity accounting for 80% of total energy use in the aluminium industry. It is estimated that energy saving in the range of 15%-20% of total energy use can be attained.
- The **textile industry** accounts for 9% of total commercial energy consumption in India, with expenditure on energy accounting for 10% -15% of total input costs for most textile mills (TERI 1996). Coal is the dominant form of energy consumed in this sector, though its share in the total energy consumed has declined from nearly 50% in 1985 to 41% in 1994/95. Correspondingly, the share of oil and gas has increased by 10% in the same period, with the share of electricity remaining fairly constant at 30% (TERI 1998). The overall energy saving potential in this sector is estimated to be 23%. Moreover, surveys show that 25% - 30% of mills have not adopted any energy conservation measure. An estimated 10% of electricity requirements in steam using mills could be met through co-generation. Further, there is scope for utilising renewable energy sources, specifically solar thermal applications for generating low grade heat.
- The main source of energy in the **cement industry** is coal, with a share of 88% of total energy consumption in the cement industry in 1994. Oil and gas and electricity accounted for 5% and 8% respectively in 1994. It is estimated that at least 10% savings in both thermal and electrical energy consumption is possible.
- The **iron and steel industry** is the largest consumer of energy in the industrial sector. Energy costs constitute 30% of total production costs. Coking coal is the primary source of energy utilised (in integrated steel plants), with a share of 65% - 80% (FRIC 1996). Energy consumption could be reduced in this sector by importing good quality coking coal, phasing out open-hearth furnaces for steel making and introducing more continuous casting.

Transport Sector

In India, the higher growth of energy consumption in the transport sector is primarily due to two structural shifts that have occurred in the sector. The first is, a rail dominant economy in 1950s, has become a road-dominant economy in 1990s. The railway despite being a more energy efficient mode of transport is now carrying a decreasing share both in freight and passenger movement. Currently, over 80% of passengers and 60% of freight are moved by roads. The second is, an inadequate public transport system which has led to an increase in the use of personalised mode of transport, particularly in urban areas. This combined with an increase in urbanisation has lead to traffic congestion, increased travel time by roads, increase in fuel consumption and increased emission of pollutants. Fuel inefficient vehicular

design and ageing vehicular fleets plying on the road not only consume more fuel per kilometre but also emit more pollutants. Railway has witnessed substantial technological advances in the form of the induction of new generation diesel locomotives with the latest traction technology. A multi-modal system in the form of container transport has emerged as an important feature of transport sector. Six out of eleven major Indian ports are equipped to handle container traffic. These improvements, though substantial, are not adequate to achieve satisfactory energy efficiency. Railway capacity has plateaued and substantial additional output is feasible only through creation of additional capacity.

Despite reforms in energy sector to achieve better energy efficiencies, the energy sector still suffers from many infirmities. In the power sector, the peak demand shortages were about 11% during 1998/99, and energy availability shortages stood at 5.5% (MoP, 1999). With this gap between demand and supply, energy management through more efficient energy use has assumed increasing importance.

The Asian Development Bank's Policy Statement for Energy Sector addresses supply side measures and demand side management to improve energy efficiency. For capacity expansion by existing facilities, assistance by the Bank could be considered only if the utilities are optimising their output from existing facilities. In addition, utilities will be encouraged to rehabilitate and retrofit in a cost-effective manner their older generating units and sub-stations to optimise efficiency of their operations and prolong their useful lives. For the demand side management of energy use, the Bank's emphasis has been on use of tools like energy audit for energy-intensive sectors to identify potential for energy saving and adopting energy efficient technologies.

In the following sections, a review of existing policies for efficient energy use is presented followed by identification of barriers to efficient energy use in energy and transport sectors and interventions required to remove these barriers. In the end, one intervention each from energy and transport sectors is developed as win-win policy interventions.

Existing Policy on Efficient Energy Use

Although the importance of energy sector was recognised as early as the formulation of first five-year plan (1951-56), it was only in 1979, due to growing fuel prices, that

the importance of energy conservation was realised. The Working Group on Energy Policy established in 1979, stressed on optimising energy use. Subsequently, in the sixth five-year plan (1980-85), the need for a comprehensive and integrated energy strategy for the country was realised with particular emphasis on new and renewable energy technologies. In 1983, the Inter-ministerial Working Group was constituted, which recommended provision for investments and subsidies in effective implementation of energy conservation measures. This Group also recommended the need to explore energy conservation options in industry, transport and agricultural sectors. The Advisory Board on Energy (ABE) attempted at an integrated energy planning for the country. ABE recommended setting up of a National Energy Conservation Organisation (NECO) backed up by comprehensive legislation on energy conservation. The seventh five-year plan (1986-91) mentioned that there is an energy conservation potential of 25% in the industrial sector and 20% and 30% in the transport and agricultural sectors, respectively. Various recommendations included management of oil demand in transport sector, energy conservation by inter-fuel substitution, and increasing the productive efficiency and capacity of already existing equipment. From the seventh five-year plan to eighth- and ninth-five year plans the major shift in energy policy is to ensure supplies at minimum possible costs and protection of environment from adverse impacts of energy utilisation. The liberalised policies of the government have paved the way for entry of private investors for energy management in the country.

Barriers to Efficient Energy Use

Despite existing policy on energy conservation and immense opportunities for efficient energy use in various sectors very little has been achieved in sectors like power, transport and industry, which are major sinks for energy. Differential fuel pricing, lack of coordinated efforts and scarcity of funds are major hindrances in achieving efficient energy use. Some of these barriers specifically for energy and transport sectors have already been discussed in detail in the Country Analysis Report. The following sections discuss in particular the barriers to efficient energy use.

Barriers in Energy Sector

- The main barrier responsible for inefficient energy use in the country is the prevalence of extensive energy subsidy. The total energy subsidy provided by

government in the energy sector amounts to US \$ 2.73 billion (coal – US \$ 1.055 billion petroleum products – US \$ 1.675 billion) and which is approximately 1% of national income (Gupta 1999). Increase in energy prices would not only result in more efficient energy use but also result in reduced emission of local and regional pollutants such as oxides of nitrogen and sulphur and carbon dioxide. The effect of subsidy on efficient use of various fuels is discussed below.

- In addition to overall energy subsidy, there also exists a cross subsidy for various fuels such as kerosene and liquefied petroleum gas (LPG) in the country at the expense of petrol and aviation turbine fuel (ATF). About 11 million tonnes of kerosene is supplied annually by state-run oil companies to state governments for supplies to ration card holders through the public distribution system (PDS). Large part of kerosene meant for the PDS is however diverted to the black market and used for adulteration of diesel and petrol (which are more expensive) leading to more pollution as these engines are not designed to use this fuel mix. Thus, not only does the subsidised kerosene not reach the target sections, but its low price also acts as an incentive for adulteration.
- In the agricultural sector, land preparation and harvesting accounts for bulk of diesel consumption whereas electricity is largely used for irrigation. Many states in India, currently provide (or have provided) free electricity to this sector. The agricultural sector accounted for 77% of the gross subsidy (subsidy on fertiliser, electricity, etc.) in the year 1998-99 (Gupta 1999). This leads to excess power consumption leading to wasteful use of water for irrigation. This in turn leads to washing away of the fertilisers applied to the top soil and need for more fertiliser to retain fertility of the top soil. Effective targeting of subsidies rather than blanket subsidies on power to the farmers will help in efficient water use for irrigation and will conserve on other resources as well.
- While coal prices have been deregulated, most of the coal-based power stations are not able to utilise better grades of coal for power generation. The reason for this is that boilers provided in these power stations are designed for utilising coal with 35%-40% ash content and these boilers cannot handle coal with a lower ash content or higher heating value.
- Although there have been gradual improvements in specific energy use by the industrial sector, the energy conservation move has not yet gained the desired

momentum. Some key factors identified to be responsible for this are listed below:

- Conflict of investment priority between energy efficient projects and capacity expansion;
 - Importance given to first-cost minimisation, disregarding the more efficient options, which often have a higher initial cost;
 - There is limited competitive pressure to reduce costs because of the growing demand;
 - Shortage of capital to fund energy efficient technologies;
 - Shortage of skilled staff and lack of knowledge/information on technological options; and
 - No check on manufacture and marketing of cheaper inefficient products.
-
- In addition to subsidy and pricing, another major policy failure in energy sector with major environmental implications, particularly with reference to power sector, arises due to extensive public ownership of power generation and distribution at the state level. Reforms have not yet made a significant dent on this extent of public ownership. With this pattern of ownership, the sector has been plagued by low revenue generation and lack of revenues for repair and maintenance of existing infrastructure by these SEBs. This results in low plant load factors (PLFs), inefficient generation and high T&D losses and low levels of consumer satisfaction.
 - The share of hydel power capacity has declined from 43% in 1970-71 to about 25% at present. The share of thermal power plants (TPPs) now stand at about 73% (the balance 2% being power generated from nuclear installations). The increasing reliance on TPPs for power generation comes from the fact that they have relatively shorter gestation period and are favoured to meet increasing electricity demand. Coal production has increased rapidly to meet the increasing reliance on TPPs, from 78 million tonnes in 1973 to 205 million tonnes in 1997/98 (TERI 1999). Moreover, with open-cast mechanised mining, the quality of coal has deteriorated with the ash content in the range of 40-45% (Bose et al. 1998). Poor quality of coal has resulted in greater consumption of coal per unit of electricity generated and higher emission per unit of generation. In addition to emission of gaseous pollutants, 65 million tonnes of fly ash are generated from TPPs every year in India (World Bank 1998).

Barriers in Transport Sector

- Cross-subsidies in fuel prices have adverse impact on transport sector also. The subsidy/price differential between diesel and petrol, with the former around less than half of the latter till very recently, has encouraged dieselisation of vehicles in the country. This is responsible for higher emission of SPM. The subsidy on kerosene, as discussed in the energy sector, encourages adulteration of diesel and gasoline leading to more emissions.
- The Indian vehicle population is dominated by two-stroke two- and three-wheelers (more than two thirds of total vehicle population) which are fuel inefficient and highly polluting.
- In India, the buses meant for public transport in cities are modelled around a truck chassis, which is basically designed for long-distance or inter-city traffic. Designing these buses for intra-city traffic can achieve higher efficiency of diesel combustion.
- The age composition of Indian vehicles shows that new vehicles (upto 5 years old) constitute only about 37% of all the registered vehicles with the remaining two thirds of the vehicle population being older. As most of these older fleets belong to the period when emission norms were absent, they are highly polluting.
- Growing level of motorization, limited road network, inadequate repair and maintenance of roads lead to traffic congestion in urban centres. This, in-turn, leads to more time spent on the road while commuting and therefore more fuel consumption and increased emissions.
- The shift in relative shares between different transportation modes (rail, road, air, water and pipeline) hold important implications for emissions due to different energy intensity of various transportation modes for both passenger and freight.
- The policy to encourage clean fuels like compressed natural gas (CNG) remains to be half hearted and ineffective due to limited gas availability in the country, limited fuel outlets and high costs for retrofitting.
- In India, the average occupancy rate for cars is estimated to be below three persons per car; in cities, the occupancy levels are even lower. This means more energy use and more emissions per passenger-km driven.

Recommendations on Interventions to remove the Barriers in Energy Use Efficiency

Key interventions required to overcome various institutional and political barriers towards integration of environmental policies and concerns in energy and transport

sectors are presented in Country Analysis Report. Out of the various interventions identified, those pertaining to energy use efficiency in energy and transport sectors are discussed in the following sections.

Interventions in Energy Sector

1. Need for an integrated energy policy;
 2. Adoption of realistic energy pricing;
 3. Incentives for adoption of cleaner technology;
 4. More efficient demand side management of energy;
 5. Reforming and restructuring the existing energy sector; and
 6. Development of renewable energy technologies (RETs).
- Need for an integrated energy policy. The initiatives taken so far in the energy sector have not fully conformed to the requirements of a sound integrated energy policy. Energy policy and reforms exercised so far are on stand-alone basis. For example, reforms in the power sector have been largely aimed at generation. Power systems consist of an integrated chain of generation, transmission and distribution, and lack of attention to the last two aspects is unlikely to yield optimal benefits. In the same vein, power itself is a subject which cannot be tackled in isolation – problems associated with fuel requirements and transportation linkages will ensure that projects have difficulty in obtaining financial closure. Same is true for oil and gas and coal sectors also. Because of these inter- and cross-sectoral linkages, unless reforms are aimed across the sectors, they are unlikely to make any impact.
 - Adopting of realistic fuel prices will lead to improvement in energy efficiency because of the following reasons:
 - When the tariff structure is changed to reflect the economic cost of production, higher prices for fuel/electricity will lead to more efficient use of energy;
 - With the removal of subsidies, electricity generators will be motivated by the commercial incentives, and they will have adequate cash flow to modernise generating plants and rehabilitate transmission and distribution system to reduce the electricity loss through inefficiency. This will result in less power generation to meet the existing demand and consequently lower level of emissions; and

- Commercially motivated producers will search for revenue-generating options like improved metering, billing, and collection procedures to increase their revenue.
- Incentives for adopting cleaner technologies. Incentives by government to power generators in terms of adopting clean coal technologies like atmospheric fluidised-bed combustion, pressurised fluidised-bed combustion, integrated gasification combined cycle technology, and smokeless fuel processes along with use of better quality of coal will help result in more power and lower emissions per unit of fuel burnt.
- More efficient demand side management of power. The World Bank study conducted for the states of Bihar and Andhra Pradesh shows that the demand side management programmes in India could reduce the total system cost by approximately 6% by 2015 and also reduce emission by 10% (World Bank, 1998). By adopting tools like energy auditing, potential areas for energy saving can be identified. This would help in optimising use of existing energy supplies.
- The average PLF of SEB-run TPPs was less than 60% in 1996-97, compared to more than 70% for central government and private sector TPPs in India. SEBs in Eastern and North-Eastern India had PLFs of 40% or less. Over the current decade, the annual loss incurred by SEBs increased almost three times from about US \$ 108 billion in 1991-92 to more than 295 billion in 1998-99 (Gupta, 1999). Some of measures to improve functioning of SEBs would be administering realistic fuel prices, better billing/metering, and cutting down on T&D losses, which can earn net revenue for SEBs.
- Develop renewable energy technologies. Adoption of renewable energy technologies like solar, wind, biomass, etc. can reduce the dependence on conventional energy sources. This will result in less fossil fuel consumption and lower emission of pollutants.

Interventions in Transport Sector

Following measures are required to improve energy use efficiency in transport sector.

1. Promotion of cleaner fuel and improved engine technologies

Replacing two-stroke engines which are fuel inefficient and more polluting by the more efficient four-stroke engines in the existing two- and three-wheeler fleets in India can result in significant fuel saving. However, a time-bound programme and

incentives from government are required to achieve this. Similarly changing to engines based on multi-point fuel injection (already introduced in India by some automobile companies) for gasoline engines and turbo-charged diesel engines for heavy trucks can also result in achieving higher fuel efficiency. Use of unleaded gasoline and low sulphur-diesel will lead to lower emissions. This can be achieved by:

- For new vehicles, use progressively stringent emission standards; and
- For in-use vehicles, periodic checking and inspection and issuance of fitness certificate.

2. Modal shift in transport options

India, from a rail-dominated economy in 1950s has become road-dominated economy in the 1990s. Road-transport consumes more energy and results in emission of more pollutants compared to rail-transport. Proper mix of road-rail transport network therefore needs to be developed to reduce the traffic pressure from roads. This would require making rail transportation more attractive to the consumer (currently railways are perceived as a rather inflexible mode of transportation). This would require reduction in cross subsidy that freight traffic provides to passenger traffic.

3. Proper land use policies for future infrastructure planning

Transport related infrastructure development should follow adopting proper land use planning for the area. This includes providing better connectivity by the road to other infrastructure such as residences, commercial places, other roads, as also city planning to reduce travel demand. The transport infrastructure should be able absorb the future projected traffic loads without causing congestion. This reduces the travel time considerably and as discussed earlier, provides an option for energy saving.

4. Adopting rational fuel pricing

As discussed earlier in this report, the existing cross subsidy on kerosene results in adulteration of gasoline and diesel with kerosene and higher emissions. Removing these subsidies and adopting a more realistic pricing for kerosene will discourage above practices and will result in overall improvement in fuel efficiency of in-use vehicles and lower level of emissions.

5. Reduction of urban congestion

This will lead to smoother movement of traffic flow, less time spent on the roads, which will lead lower fuel consumption and lower emissions. This could be pursued by adopting the following:

- Augmenting the public transport system; and
- Using a combination of market based instruments (MBIs) like fuel taxes, emission taxes, etc.

6. Promotion of non-motorised travel options

Non-motorised travel options particularly use of bicycles for shorter travel distances results in saving fuel. However, perquisites for passengers favouring this mode of transport would be provision of separate bicycle lanes on most of the roads and need to travel short distances.

Win-Win Policy Interventions

In this section, two key policy interventions, one for energy sector (*need for an integrated energy policy*) and one for transport sector (*reducing urban traffic congestion*) are developed as win-win policy interventions detailing the measures and steps to be undertaken to implement the recommended policies.

Need for an Integrated Energy Policy

The period from 1991 to the present can be regarded as a transition period for the Indian economy and the energy sector in particular. Despite various policy interventions, a review of the policies in the past five years would indicate that reforms need to be made more broad based. Thus, power cannot be tackled in isolation – problems associated with fuel requirements and transportation linkages will ensure that projects have difficulty in obtaining financial closure. It would be difficult to promote competitiveness and efficiency in the power sector without corresponding changes in the fuel sector. In the hydrocarbons sector, policy interventions are yet to address issues on developing alternative fuels, improving institutional set-up, improving transportation network, and setting up firm time plans for deregulation. Since energy sector consists of inter-linked chains; reforms in one link are unlikely to be successful without concomitant reforms in related areas.

An integrated energy policy is proposed which steers the energy sector towards an efficient market-based structure in the short and medium term. In the longer term, the

integrated policy targets regulation of natural monopolies as also the internalisation of non-market costs, namely, social and environmental.

Energy Sector Linkages

Hydrocarbons represent the most rapidly growing fuel segment in India's energy sector. Several factors are responsible for India's growing dependence on hydrocarbon fuels and for an increase in imports. While it is difficult to neatly separate factors on the demand side from those on the supply side as the following analysis would indicate, for ease of presentation, it is useful to explore linkages between energy consuming sectors and alternative forms of energy.

Demand side

The important linkages between fuels consumed in different sectors are discussed below.

Transportation – Policies and structural change in the transport sector have a major impact on liquid fuels in particular. With a shift towards vehicles using CNG, for instance, the mix between liquid fuels and natural gas would change correspondingly. Also, the growth of personalized automobile transport versus public transport, including the shift from rail to road would be the most important factor in determining hydrocarbon demand in the future.

Captive Generation – In recent years, rapid growth has taken place in captive generation with estimates of about 20000 MW of capacity in this form of power supply. At present, a large share of it based on oil products. The basic reason for growth in captive generation is failure of supply of power from the grid. This fact brings out the interdependence between grid-based power and other fuels.

Agricultural pumpsets – In this case also demand is dictated by the nature of agricultural operations, and the availability of electric power, which is generally the preferred option for running agricultural pumpsets. With unreliable and inadequate power supply in rural areas farmers shift to the use of diesel pumpsets.

Residential – Hydrocarbons are used on a large scale as cooking fuels particularly in urban as well as in some rural areas. With the harmful health effects of cooking with biomass fuels, there would be growing public pressure for supply of hydrocarbons as

cooking fuels in homes. This would be particularly relevant in the case of rural areas, which are as yet largely unserved by supply of LPG and with very poor supply of kerosene.

In each of the above, end uses, while current technologies favour hydrocarbons, accentuated by shortages and unreliable supply of power, there are always options for inter-fuel substitution.

Supply Side

The most important nexus between different fuels is for supply of energy in power generation. Currently the options that can be considered for power generation in the coming decades include use of natural gas, oil products and coal. To this can also be added greater use of renewable forms of energy such as wind, photovoltaics and biomass as well as nuclear power in the coming decades. One major constraint which leads to a growing role for gas and oil being used for power generation are the problems afflicting rapid increase in coal production and use. For instance, one scenario for coal demand in the year 2010 indicates around 900 million tonnes of coal use, but realistically if only 400-500 million tonnes can be produced, oil and gas will have to fill up the gap. On the other hand, if coal production responds adequately, investments in supply of hydrocarbons and related infrastructure to the same extent may not be justified.

Natural gas has been projected to be the preferred fuel given its efficiency of combustion and limited environmental impacts. However, availability of the fuel is limited and there are competing demand sectors, namely, power generation, fertiliser manufacturing, other industry, transport (as CNG) as well as the commercial and residential sectors. Such competing demands mandate an integrated analysis to determine the best use of limited energy resources.

Choices need to be made on the basis of assessments involving coal, oil, natural gas and power generation, both from fossil fuels and renewables.

Integrated Energy Policy

The need for an integrated energy policy is evident from the inter-linkages that exist between different energy supply sources as well as the energy consuming sectors. An integrated policy will enable the following:

1. Integrated cost assessment at the national level (as opposed to project level) to optimize the cost of energy supply and use. This in turn will provide appropriate signals for investments required to prevent energy shortages in the medium - and long-run.
2. Minimization of environmental damages resulting from energy consumption. Including the cost of environmental damages will provide a level playing field for environmentally benign energy options and enable a fuel-technology mix that minimises costs of environmental damages.
3. Efficient regulation of the energy sector.
4. Indicate areas where R&D investments have to be increased for timely development of alternatives to guard against balance of payment repercussions and issues related to energy security

Energy Sector Investments

Coal production can be increased rapidly if major reforms are introduced in this industry to bring about greater private sector investments and higher efficiency in the entire cycle, including transportation of coal. But a much more compelling case exists for reforms in the power sector. In particular, if power sales do not even generate adequate revenues to cover average costs, then viable fuel supplies cannot be maintained, and investments to ensure adequate supplies will not be forthcoming. Security of revenue inflows at the ultimate end use of the power sector is absolutely essential for investments upstream in fuel supplies for power generation.

Integrated Energy Pricing

In order to reduce the distortions in energy supply and usage and in preparation for a deregulated energy sector, energy pricing would also need to be integrated. This is essential, for instance, for providing renewable forms of energy a level playing field, particularly in some rural areas, where current power tariffs, which are highly subsidised, create misallocation of resources

Diversification of supply options

In the longer term, India must develop a major market for the use of renewable energy technologies. India has made a promising beginning in this field, but considerable progress has yet to be made in internalizing the environmental costs of conventional energy through rational pricing and in reducing the cost of renewables. Major commercialization of these technologies will require another 20 to 25 years.

Shell, BP and several other oil companies are, therefore, entering the renewable energy field aggressively¹. It is time for India's oil companies also to make an entry in this area, because existing marketing infrastructure makes it possible for them to supply alternative forms of energy efficiently in various parts of the country depending on economic conditions prevailing. This would also allow optimal choice of energy sources, such that pressure on demand for conventional and polluting sources of energy is reduced correspondingly.

India is also making enormous efforts toward increasing the use of renewable energy resources, but international assistance and partnerships with overseas organizations would be helpful here as well.

Coal Policy Options: Towards Cleaner Coal

While India is likely to increase its coal consumption over the next 15 to 20 years, the environmental consequences of this can be mitigated by the adoption of clean-coal technologies. Among new technologies, coal gasification for power generation has considerable value in terms of energy-use efficiency and the minimization of environmental impact. The international community, including the private sector and multilateral organizations could facilitate India's move towards clean-coal technologies.

For the present, coal production is unlikely to diminish even with a large-scale increase in the use of renewable energy resources. On the contrary, coal use could receive a major boost with the development and use of coal gasification technologies, which convert coal into gas.²

Another suitable technology for India is that of underground coal gasification (UCG). While work on gasification of coal at the surface is far more advanced than *in situ* gasification underground, UCG has many advantages. Among them are the ability to exploit coal reserves at a much greater depth than is commercially viable for mining, far less detrimental environmental effects and a much higher heating value of gas produced by this process relative to surface gasification. UCG also appears to be

¹ One scenario for the year 2050 developed by the multinational Shell indicates 50% of the total energy of the world coming from renewables by the middle of the next century.

² Coal gasification occurs through the partial combustion of coal with air or oxygen, which produces gas as a mixture of carbon monoxide and hydrogen. This gas is generally cleaned to remove certain contaminants and then fed into a gas turbine for power generation.

cheaper than surface gasification, and the capital investment necessary for such plants may be significantly lower.

Organizational Changes

In the short term, there appear to be no easy solutions to resolve India's energy problems. Actions require hard decisions — most critically, the opening up of all segments of the energy supply industry to the private sector. Preceding such a stage, strong and independent regulatory bodies need to be established to safeguard the interests of producers and consumers in pricing decisions and improvements in performance and efficiency. Only when an efficient market is developed through institutional changes will supply respond to increasing demand, thus eliminating the physical shortages that exist in energy supply today.

The changing structure of the energy sector also entails the creation of an environment where the private sector will be called upon to play a major role and the role of the government would shift from being a producer of goods and services to a facilitator. Under such an environment, the Government or its regulators would need to set transparent rules under which the private sector operates. So far, India's approach to independent regulation has been industry specific. Rapid advances in technology, and market liberalisation are leading to the convergence in industries. For example, gas and electricity industries, like in other countries, are expected to move into each other's markets, as power generation in electricity industry will make increasing use of gas as input. In India, so far, there are independent regulators in electricity sector at the federal level, and more than 10 provincial electricity regulators. The Government is also considering positioning of independent regulators in the oil & gas industry: there is a proposal to have three regulators each at the upstream sector, downstream sector and gas industry sector (Saha 1999). The Government is also reviewing its regulatory framework in the coal sector. In view of the increasing convergence of the energy sector industries, regulation cannot be compartmentalised since regulatory decisions in one industry would impact on the other. The timing is now opportune for creating a common regulator in the energy sector, and further delays in this aspect would make it difficult to merge the different regulators at future dates due to opposition from vested interests.

In view of the need for integrated energy pricing that minimises, if not eliminates, distortions in energy supply mix and use, the country would have to move towards

multi-utility and multi-fuel regulatory commissions. There is some danger in the large number of regulatory bodies that are springing up in different parts of the country. These would not only introduce inefficiencies, but also contradictory decisions that do not lead to efficient allocation of resources.

Integrated Energy Decision-making

It is also essential for energy policy in the country to be guided by the development of two or three comprehensive energy models on the basis of which regular updating and validation of different scenarios can take place. For effectiveness and efficient inputs from such modelling activities, it would be preferable for this to be sourced from an organization outside the Government and based on models that have already been developed to cover the Indian economy. Such modelling activities should, however, be guided by a steering committee of Government officials, so that there is perfect coordination between the intellectual effort required and practical application necessary for decision making. The models used also should include environmental choices at least at the aggregate level, while specific project investments would be guided by local environmental factors and economies as is generally the case. A structure needs to be evolved for coordinated decisions in the energy sector within the Government of India, and a mechanism for continuous review and analysis. Planning and regulatory bodies can use results from these integrated models.

In effect, an integrated energy policy, which would develop a well-structured supply side of the industry, encourage efficient demand side management, outline optimum renewable energy supply, promote sustainable energy-environment linkage, and outline well-conceived regulatory agencies, would no doubt result not only in establishing sustainable energy usage by enhancing the energy use efficiency but also because of consumption of less energy will result in lower emissions and less environmental degradation. Optimum utilisation of fossil fuel augmented with use of gasification technologies for biomass fuels will provide access of energy to poor of the country also. This would result in enhancing their quality of life since it would save them from harmful effects of emissions especially indoor air pollution. This means less expenditure on health related illness due to indoor-air pollution. The savings thus made can be diverted to more constructive use. Adopting integrated energy policy thus would provide a win-win option in terms energy saving, improvement in environment and improvement in health status of poor.

Reducing Urban Traffic Congestion

Background

In India, presently there is no transport policy for urban areas. Transport planning is therefore left to the discretion of the individual local urban authorities. The vehicle population in India has grown rapidly from 1.8 million in 1971 to 37.2 million in 1997. The more disturbing trend here is that just 23 metropolitan cities account for over 10 million vehicles in the country. Thus a third of the total vehicles fleet caters to only 8.37% of the countries population. The percentage of private modes (two-wheelers and cars) to the total number of registered vehicles in India has increased from 65% in 1971 to 82% in 1997 (TERI 1999a). In absence of any integrated urban transport policy, there has been a growth in the share of personalised vehicles in the last two decades. The public transport system has not been able to keep pace with the growing travel demand resulting in usage of more personalised mode of transport in the urban areas. The present system has not given enough incentives to the State transport Undertakings, to improve their financial performance. This has lead to the following impacts:

- Reduced travel speeds and increasing journey time.
- Increased fuel consumption
- Increasing emissions from urban transport sector
- Consequent severe environmental and health impacts

The use of cleaner alternative fuel and improved vehicle technologies are some of the other interventions that are essential for reducing total emissions from the transport sector. As on 1 April 1998, nearly 80% of the total vehicles registered in the country were pre-1996, the year when stringent mass emission norms for new vehicles were introduced. About 70% of these are two-wheelers and three-wheelers taken together. Old Vehicles would cause much more pollution than the new vehicles even when the new vehicles do not confirm to stringer norms. Therefore an integrated urban transport policy focusing on these issues is required (TERI 2000).

Strategy to develop an Integrated Urban Transport Policy

In view of the above background following strategies need to be adopted to achieve over all energy efficiency and environment-friendly urban transport system.

1. Periodic inspection and maintenance of in-use vehicles.

2. Reducing urban congestion by (a) promoting mass transit system and facilitate a shift from personalised to mass transport systems (b) use of traffic management measures to ensure smoother mobility of traffic.
3. Promote cleaner fuel.
4. Introduce improved technology.
5. Integrated land use transport planning including telecommuting and development of satellite towns.

Need for a unified metropolitan transport authority

In the absence of an integrated policy and co-ordinated approach, urban transportation has grown in response to demand in a haphazard manner. As of today, fragmentation and overlapping of responsibility and authority has made planning and management of urban transportation a complex task. To illustrate this, as many as 16 agencies directly or indirectly influence the provision of transportation infrastructure, its operation and regulation in Delhi. These include Ministry of Surface Transport, Department of Transport, Delhi Traffic Police, Municipal Corporation of Delhi, New Delhi Municipal Committee, Delhi Transport Corporation, Public works Department and Delhi Development Authority. In the absence of such a focal body responsible for managing traffic and transportation in Indian cities, it would be difficult to implement energy efficient and environment friendly policies for urban transport sector in Indian cities.

Policy interventions

The policy interventions required for reducing emissions from the urban transport sector in a chronological order are given below.

1. **Unified metropolitan transport authority:** Grounded in this vision, as highlighted above, it would be essential that a Unified Metropolitan transport Authority (UMTA) be established in megacities in India. Formulation of such is essential to ensure that the following policy interventions are implemented effectively in the country.
2. **Compulsory inspection and maintenance programme for inuse vehicles (Short term):** The improved technology would only reduce emissions from the new vehicles. However a compulsory inspection and maintenance programme must be formulated so as to reduce emissions from the inuse vehicles and maintain the standards of new vehicles. Additional adequate infrastructure would

have to be provided at the authorised service stations for proper inspection and maintenance of vehicles.

3. Reduce urban congestion

a) Promote mass transit

More buses (Short and medium term)

- **Augmentation of public transport:** As mentioned above, one of the major causes for the phenomenal increase in the share of private modes in vehicle fleet is the inadequate supply of public transport. Thus, as a first step, the public transport service must be augmented immediately. For instance, in the city of Delhi where the public transportation system is completely road based, to cater to 75% of the travel demand by public transport as recommended by the government would require additional 9500 buses with an already existing fleet of 13500 buses. This again would imply significant investments (about 21 million US\$ in the case of Delhi).
- **Improvement in operational efficiency of fleet operators:** The public bus operators must improve their performance in terms of using the existing fleet more efficiently. The three parameters that indicate the level of operational efficiency are fleet utilisation (proportion of the fleet on road to the total fleet), vehicle utilisation (kilometres per bus per day), and the load factor (number of people in a bus on average). Increases in efficiency of each of the above parameters by 10% would imply that the bus fleet required would be lower by nearly 25%.
- **Ensuring financial viability of public bus fleets:** While improvements in operational efficiency would lower the operating costs of bus fleet operators; it would not be adequate to ensure the financial viability of the fleet augmentation plans. For instance, in Delhi with the above-proposed fleet increases, a 45% increase in revenue would be required to ensure a return of 12%. Thus along with improvements in operational efficiency, increases in revenue should be considered to make public transport augmentation a viable proposition.
- **Increase in utilisation of public transport:** The benefits from increased public transport service would not be realised unless a shift from private to public modes is realised. For this the ownership and utilisation of personal vehicles should be discouraged. This would involve raising the sales tax and/or registration fee for new vehicles and also a vintage tax that could be levied through the annual insurance renewal.

Rail based mass transit (Long term)

While a short-term strategy is to augment public transport, but a long-term strategy should be formulated to encourage the rail based mass transport system within the city. This would essentially result in a modal shift from road to rail based transport and would lead to more energy efficient transport system.

b) Traffic management measures (Short and medium term)

The traffic restraint and demand management measures should be enforced to ensure faster and smoother movement of traffic. These measures include:

1. Physical restraint measures such as one way street, banning turns and activating slip lanes, exclusive pedestrian zones, and engineering measures such as widening of roads and provision of exclusive bus lanes. These would also include up-gradation of infrastructure for promoting non-motorised travel options.
2. Market based -fiscal demand management measures such as imposing congestion charges for entry of private vehicles in delineated congested areas and imposing differential parking fees for private vehicles.

3. Promote cleaner fuel (Medium to Long term)

- **Total lead phase out:** There should be a total lead phase-out in gasoline in the country³. The benzene level in the gasoline should also be reduced from 5% to 1%.
- **Ultra low sulphur diesel:** Ultra low sulphur diesel (0.003 sulphur content) should be introduced with after treatment devices such as oxidation catalyst and particulate traps.
- **CNG fuel:** CNG as a transport fuel should be encouraged, wherever it is economical and environmentally more beneficial as compared to conventional fuels like gasoline and diesel. It is a very attractive alternative, however its extensive utilisation might not be possible due to fuel supply constraints.
- **Battery operated vehicles:** The use of battery operated vehicles should be encouraged by giving them financial incentives.

4. Introduce improved technology (Long term)

³ This measure has already been implemented in India

- **Covert 2 stroke to 4 stroke:** The manufacturing of 4 stroke engines for the Two wheeler and the Three wheeler segment should be encouraged by banning the registration of the 2 stroke engine manufactured vehicles.
- **Stricter norms:** The norms as proposed by the Supreme Court for Delhi should also be made mandatory for the entire country and for all types of vehicles. The Euro II norms and beyond would ensure that a cleaner vehicular technology by all the manufacturers.

5. **Integrated land-use and transport planning** (Long term) It is an essential policy intervention for ensuring smoother mobility of traffic, but due to its rather long term implementation time period (more than 15 years) this option has not been discussed in detail. Telecommuting and integrated development of small and medium towns are some of the other future long-term options for reducing urban congestion.

Reducing urban traffic congestion by adopting various means discussed above will result in smoother movement of traffic. This in turn results in less time required to cover the same distance and less time spent by commuters on the road. Exercising options like better maintenance of existing vehicles, introduction of fuel efficient transportation options, development of mass transit options and integration of land-use planning with transport policy will result not only fuel saving but also in less emissions as requirement of the fuel for the same unit of transport goes down. Reducing urban traffic congestion, therefore is definitely a win-win option in terms of saving fuel and reducing emissions by saving fuel.

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